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Solanum sejunctum (Solanaceae), a new functionally dioecious species from Kakadu National Park, Northern Territory, Australia

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ABSTRACT

A new species of functionally dioecious *Solanum*, *S. sejunctum*, is described from Kakadu National Park, Northern Territory, Australia. It is compared to *S. asymmetriphyllum* Specht, a similar species from the same region. Updated identification keys are provided for *Solanum* in the northern Northern Territory and Kakadu National Park.

KEYWORDS: Solanaceae, *Solanum*, new species, Kakadu National Park, Northern Territory, Australia, dioecy.

INTRODUCTION

This new species was first collected by L.A. Craven in 1973, at which time it was identified as *Solanum asymmetriphyllum* Specht. It was first recognised as a separate taxon by Brennan (1990) on the basis of its anomalous indumentum characteristics and was subsequently segregated in the Northern Territory Herbarium (DNA) by I. Cowie in the latter half of the 1990s, first as *Solanum* A55445 Mt Brockman (Cowie and Albrecht 2001) then as *Solanum* sp. Mt Brockman (L.A. Craven 2371) (Cowie and Albrecht 2004, 2005).

The new taxon belongs to a group of nine recognised species from northern and north-western Australia (two in Arnhem Land, Northern Territory, and seven in the Kimberley region of Western Australia), that are functionally dioecious (*S. asymmetriphyllum, S. cardniforme, S. cataphractum, S. cunninghamii, S. dioicum, S. leopoldensis, S. petraeum, S. tudununggae* and *S. vansittartensis*), although strictly, in terms of gross floral morphology, they could also be described as androdioecious (Symon 1979). The male plants have cymes of numerous smaller flowers while the fruit-bearing plants have single, larger hermaphroditic flowers. However, within this group the pollen produced by the anthers of hermaphroditic flowers has been found to be mostly nongerminable and inaperturate, and does not contribute to fertilisation, thus making the flowers (plants) functionally female and the overall sex form functional dioecy (Anderson and Symon 1989). Pollen produced by the hermaphroditic flowers is believed to serve mainly as a reward for pollinators in the same way that other species provide nectar (Anderson and Symon 1989). Treatments prior to this laboratory study were understandably inconsistent in assigning a sex form to members of the group, leading to some confusion. Symon (1970, 1971, 1981) and Purdie *et al.* (1982) described them as dioecious, whereas Symon (1979) rejected the notion of truly dioecious *Solanum* and revised them as androdioecious. Most of the species in this group are confined to broken sandstone terrain in the monsoon tropics, though some extend to adjacent sand plains in Western Australia.

Results of recent analyses using molecular phylogenetic methods (Martine 2006; Martine *et al.* 2006) and which support the hypothesis that *S. asymmetriphyllum* and *S. sejunctum* sp. nov. are a closely related pair of distinct taxa are presented below, as are brief remarks as to their relationship with other Australian species previously placed in section *Melongena* by Symon (1981).

Institutional acronyms used are: AD (State Herbarium of South Australia, Plant Biodiversity Centre, Adelaide, SA, Australia); CANB (Australian National Herbarium, Centre for Plant Biodiversity Research, Canberra, ACT, Australia); CONN (George Safford Torrey Herbarium, University of Connecticut, Connecticut, USA); and DNA (Northern Territory Herbarium, Palmerston, NT, Australia).

SYSTEMATICS

Solanum sejunctum K. Brennan, C. Martine and D. Symon sp. nov.

(Fig. 1)

Solanum asymmetriphyllum auct. non. Specht 1958: 295.

Solanum sp. Brennan, 1990.

Solanum A55445 Mt Brockman Cowie, I.D. and Albrecht, D.A. 2001.

Solanum sp. Mt Brockman (L.A. Craven 2371) Cowie, I.D and Albrecht, D.A. 2004 and 2005.

Latin diagnosis. Suffruticosa ad 1m alta. Caules densim pubescentes, sparsim aculeati aut inermes. Folia lata et lanceolata, basi inaequali, 11–13 cm longa, 4.5–5.5 cm lata, margine integro, apice acuto, densim pubescentia pilis sessilibus aut stipitatis supra et infra. Plantae dioeciae; flores feminei solitarii per photo; calyx aculeis brevibus et conicis, baccum includens. Bacca 2 cm diam., viridis. Cymae masculinae ad 11 cm longae, ferentes usque as 40 flores sequentiter exutas, late stellatus. Antherae poricidales.

TYPUS: Australia, Northern Territory, north facing wall in central part of Mt Brockman. 12° 44' S, 132° 54' E, 23 February 1973, *L.A. Craven 2371* [fruiting plant] (holotype: DNA; isotype CANB *n.v.*).

Other specimens examined. NORTHERN TERRITORY; Alligator Rivers Region: Mt Brockman, 12° 44' S, 132° 54' E, 23 February 1973, L.A. Craven 2375 [male plant] (CANB, DNA); Radon Gorge ca. 12 km south of Jabiru, 12° 45' S, 132° 54' E, 10 June 1978, P.K. Latz 7690B [fruiting plant] (DNA); Radon Gorge ca. 15 km south of Jabiru, 12° 45' S, 132° 55' E, 11 June 1978, P.K. Latz 7707 [fruiting plant] (DNA); Nourlangie Rock, 12° 51' S, 134° 49' E, 17 June 1984, K. Brennan, 431 [fruiting plant] (DNA); Mt Brockman outlier, 15 km south east of Jabiru along Baroalba Creek, 12° 47' S, 132° 56' E, 20 April 1989, R.W. Johnson, 4690 [male plant] (DNA); Mt Brockman, 12° 47' S, 132° 56' E, 20 April 1989, J. Russell-Smith, 8043 and D. Lucas [fruiting plant, 2 sheets] (DNA); Kakadu National Park, Magela Creek catchment, 12° 49' S, 133° E., 11 April 1995, J. Russell-Smith, 10367 and D. Lucas [fruiting plant] (DNA); Magela Creek catchment, 12° 49' S, 133° E, 12 April 1995, I. Cowie 5656 and K. Brennan [fruiting plant] (DNA); E Koongarra Saddle, 12° 50.8 S, 132° 51.7 E, 19 May 2004, D. Symon 17105 and K. Brennan [male plant] (AD); on Nourlangie side of Koongarra Saddle, 12° 49' S, 132° 53' E, 19 May 2004, C.T. Martine 730, K. Brennan, D. Symon and H. Toelken [male plant] (AD, CONN), Fig. 2; Koongarra Saddle, on east bank of Baroalba Creek, 12° 49.565' S, 132° 53.213' E, 19 May 2004, C.T. Martine 735, K. Brennan, D. Symon and H. Toelken (AD, CONN).

Description. A clonal shrub with erect stems to 1 m, branching above. Branches unarmed or with a few small prickles to 1 mm long, densely pubescent with sessile and stipitate stellate hairs. Petiole 1.25–2.5 cm long, unarmed or with a few conical prickles to 2 mm long. Leaves somewhat variable in size, lower and earlier leaves 11–13 cm long, 4.5–5.5 cm wide, upper and later leaves 5–8.5 cm long, 2.5–3 cm wide; lamina ovate-lanceolate. Leaf base oblique with up to 6–7 mm between insertion of margins; apex acute, margin entire. Upper leaf surface unarmed, pubescent with sessile and stipitate stellate hairs, lamina sometimes visible, grey-green to dull khaki-green; lower leaf surface densely pubescent, lamina obscured, paler grey-green. Bisexual flowers (from photograph only – no precise scale) solitary, corolla relatively large broadly stellate, acumens present, anthers closely erect, poricidal, style and stigma exceeding the anther column, stigma conspicuous. Male flowers: cyme unarmed, to 11 cm long, simple or shortly branched above, bearing up to 40 flowers shed from base in succession, flowers only 1 or 2 open at a time, more or less paired along rachis; pedicel c. 6 mm long; calyx lobes usually 5, rarely 3 or 4, lanceolate, 6 mm long, equal or unequal unarmed, acumen 1 mm, corolla broadly stellate to pentagonal, deep mauve, lobes 1 cm long with 1–1.5 mm inflexed acumens, filaments c. 0.5 mm long (i.e. anthers nearly sessile), anthers 5 mm long, lanceolate, poricidal; ovary and style vestigial, 1.5 mm long. Fruit a berry, almost wholly enclosed in calyx; fruiting pedicel c. 7 mm long, fruiting calyx c. 3 cm diameter, 2.5 cm long, densely minutely pubescent and with conical prickles 1.1–3 mm long; calyx lobes flattened, 10 mm long, 2 mm wide, scarcely leaf-like, of firm texture. Fresh berry not seen, dried specimens with berries to c. 2 cm diameter, drying near black. Seeds, numerous, immature, c. 2.5 mm long, ovate, reticulate.

Distribution and ecology. *Solanum sejunctum* is known primarily from the Mt Brockman outlier in Kakadu National Park and a small area immediately to the east, on the western edge of the Arnhem Land escarpment (Fig. 2). All collections have been from areas of dissected sandstone with plants often reported growing in fissures on the tops of sandstone boulders in, or near, forest dominated by *Allosyncarpia ternata* (Myrtaceae). Some other *Solanum* species in the area (*S. clarkiae* and *S. echinatum*) are known to proliferate after fire and are often regarded locally as 'fire weeds' but this does not appear to be the case for *S. sejunctum*. It has never been reported as common, which is highly significant given that the Mt Brockman outlier is both periodically burnt and visited frequently by botanists. Flowering and fruiting material has been collected during the early part of the dry season from April to June.

Solanum sejunctum occurs in the same general region of Kakadu National Park and occupies much the same habitat as *S. asymmetriphyllum* but the two species have not been recorded growing together. *Solanum asymmetripyllum* has two distinct centres of distribution; one to the north of Mt Brockman around the East Alligator River and another to the south near Deaf Adder Gorge (Fig. 2). We also note

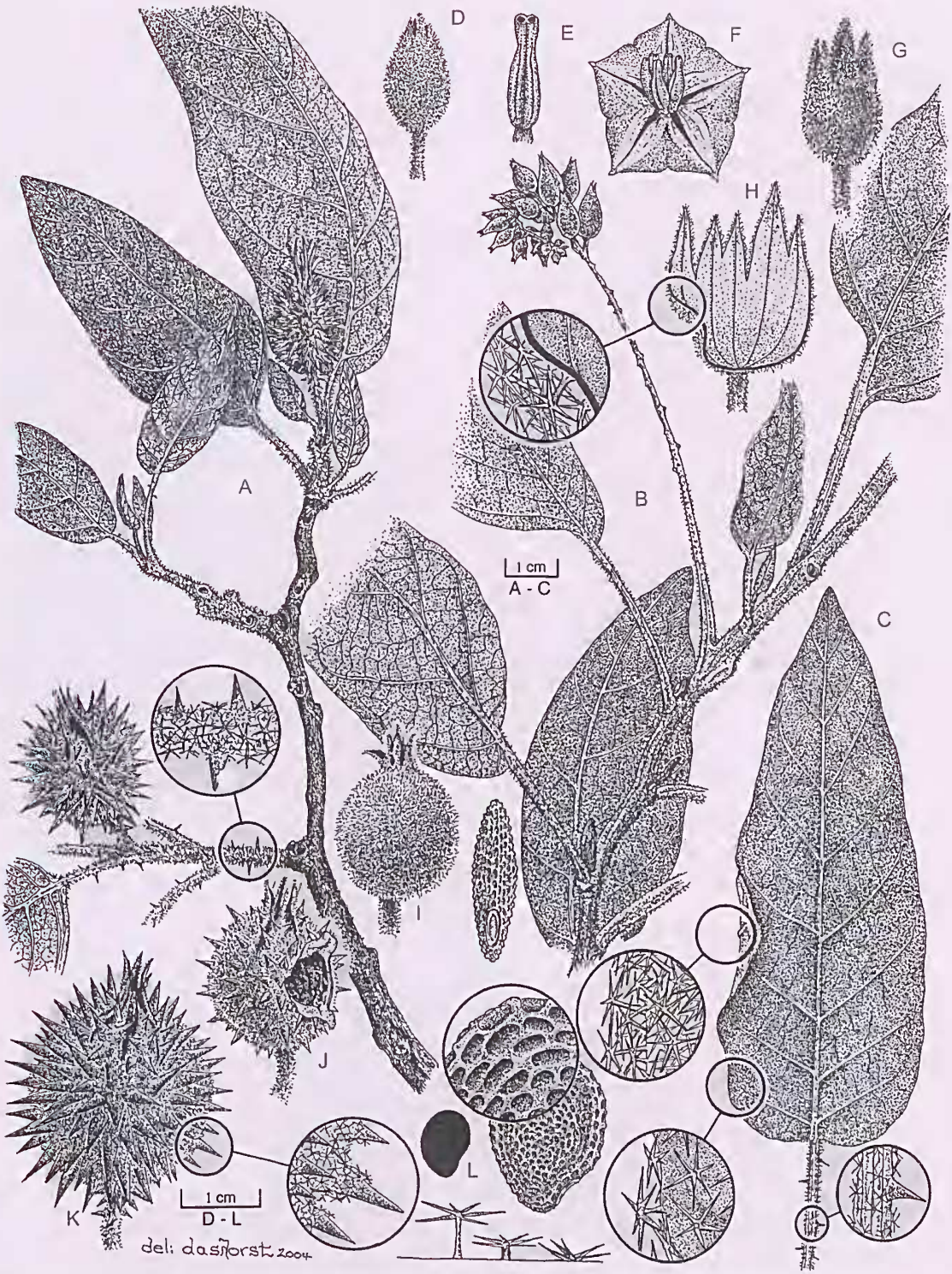

Fig. 1. *Solanum sejunctum* sp. nov. **A**, twig of fruiting plant illustrating leaves, pubescence, prickles, bud and fruiting calyces; **B**, twig of male plant illustrating leaves, pubescence, prickles, cyme, calyx and corolla; **C**, leaf showing details of pubescence and prickles; **D**, male flower bud; **E**, anther; **F**, male flower; **G**, enlarged male calyx; **H**, calyx of male flower; **I**, **J**, **K**, variation in mature fruit; **L**, seed. Fruiting plant based on *Craven 2371*. Male plant based on *Craven 2375*. Seed based on *Latz 7707*.

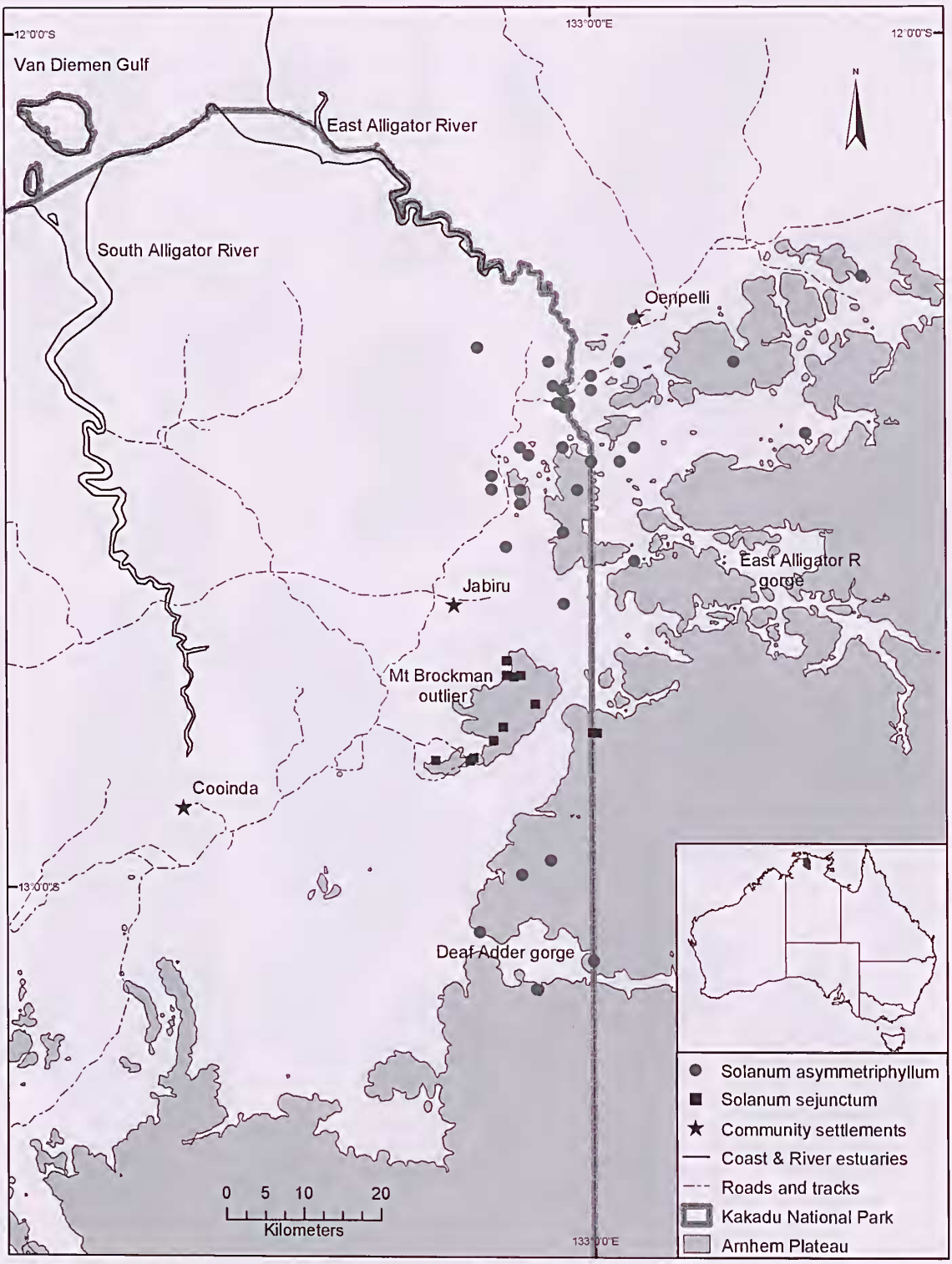

Fig. 2. Distribution of *Solanum sejunctum* and *S. asymmetriphyllum.*

that the leaves on collections of *S. asymmetriphyllum* from the south, around Deaf Adder Gorge, are typically lobed with prickles on the upper surface, whereas the leaves of those from northern populations are usually unlobed and unarmed.

Remarks. *Solanum sejunctum* is similar to *S. asymmetriphyllum*, which occurs in the same region, but the two species may be readily distinguished by reference to a range of vegetative and other characters. The older stems of *S. asymmetriphyllum* become woody with corky bark whereas corky bark has not been observed on *S. sejunctum*. The leaves of each species are highly distinctive; the upper leaf surface of *S. asymmetriphyllum* is almost glabrous apart from some minute stellate hairs on the veins and the leaves dry and markedly discolorous, dark green above and pale below. By contrast, the upper leaf surface of *S. sejunctum* is uniformly, densely pubescent above and the leaves dry and almost concolourous, pale above and below. On inflorescences of male plants the prickles on the calyx of *S. asymmetriphyllum* are thin and slender and up to 10 mm long, whereas those on the calyx of *S. sejunctum* are short and conical and only 2–3 mm long. The male inflorescence of *S. asymmetriphyllum* is simple or compound while that of *S. sejunctum* is simple or only very short branched.

Molecular phylogenetic analyses using ITS (nuclear ribosomal RNA) (Martine *et al.* 2006) and *trnK-matK* (chloroplast DNA) (Martine 2006) sequence data show strong support for the sister relationship of *S. sejunctum* and *S. asymmetriphyllum*, as well as the recognition of *S. sejunctum* as a separate species (Fig. 3). These analyses have also demonstrated that the relationship between the '*sejunctum-asymmetriphyllum*' clade to the rest of the Australian *Solanum* section *Melongena sensu* Symon is unclear. However, phylogenetic analyses using both molecular and morphological data provide some support for a larger dioecious clade in which the two Kakadu species are a sister group to the seven non-Kakadu species (Fig. 3) (Martine 2006). In contrast, the placement of the andromonoecious species also included in Australian *Melongena sensu* Symon (1981) is problematic, and they may not be as closely related to the dioecious species as previously thought. Based on current work in the *Solanum* subgenus *Leptostemonum* (Levin *et al.* 2006) in which a recent radiation of Old World 'spiny solanums' is apparent, it is clear that the evolutionary relationships among most Australian, Asian, and African eggplant relatives will remain difficult to elucidate without a comprehensive sampling of taxa and the utilisation of more informative gene regions.

Conservation status. *Solanum sejunctum* is confined to rugged sandstone terrain in Kakadu National Park and remote parts of western Arnhem Land immediately adjacent to the park. Therefore, it is not threatened by impacts arising from current or prospective industrial or pastoral development. However, the species has a limited distribution (around 150 km^2) and is generally noted as being sparse within its range, so the total population is probably small. There is currently no knowledge about whether the species is self-sustaining or in decline, or to what extent it is affected

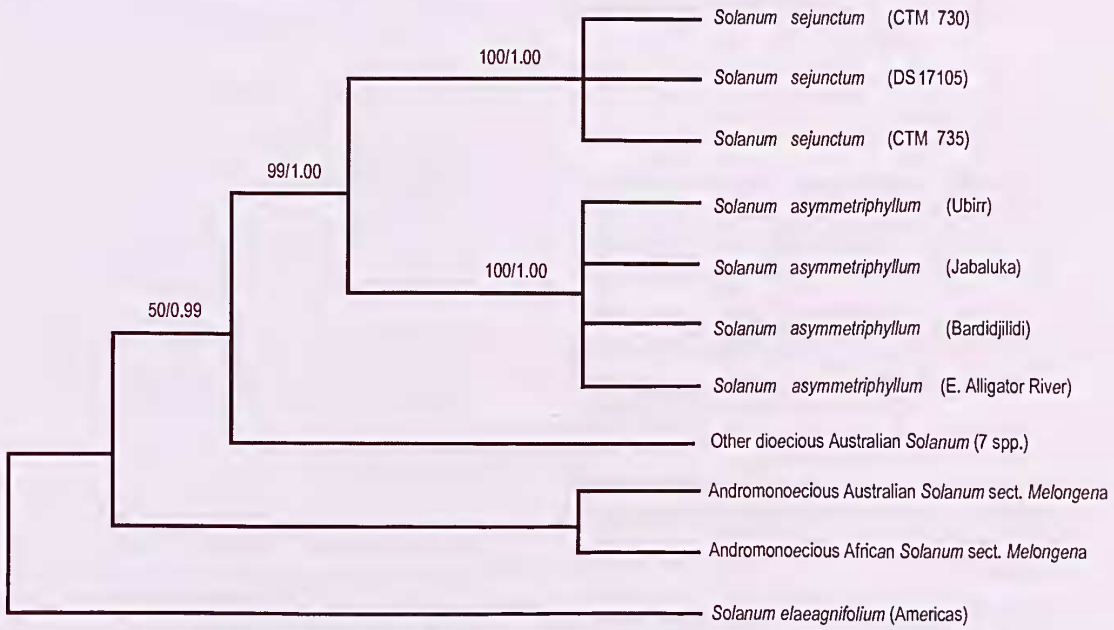

Fig. 3. Representative cladogram based on Martine (2006) showing the phylogenetic position of *Solanum sejunctum* as indicated by analysis of combined molecular (ITS, *trnK-matK*) datasets. First numbers are parsimony bootstrap values; second numbers are Bayesian posterior probabilities.

by contemporary management activities such as prescribed burning. We therefore refrain from assigning a threat rating under IUCN criteria. This should be determined later by reference to additional targeted field searches and a population monitoring program.

Etymology. The specific epithet *sejunctum*, separated or isolated, is used in a double sense in that the species has a distribution mostly confined to a single, isolated sandstone outlier and that it also occurs primarily as widely separated plants.

Revised key to *Solanum* in Kakadu National Park and adjacent western Arnhem Land

1a. Sprawling, mostly prostrate subshrub; leaves usually < 6 cm long ..... *S. echinatum*
1b. Erect or spreading shrub or subshrub; leaves mostly > 6 cm long 2

2a. Annual or biennial subshrubs to 1 m high, not clonal; stems densely prickly; calyx lobes in fruit finally reflexed, berry exposed ..... *S. clarkiae*
2b. Perennial shrubs to 2 m high, clonal; prickles on stems scattered or absent; calyx lobes in fruit not reflexed, berry almost wholly enclosed 3

3a. Leaves dark green and more or less glabrous above, usually much paler and pubescent below; calyx prickles thin and slender, to 10 mm long ..... *S. asymmetriphyllum*
3b. Leaves grey-green, densely pubescent above and below; calyx prickles conical, to 3 mm long ..... *S. sejunctum*

Revised key to *Solanum* in the Northern Territory north of 15° S

1a. Herbs or short-lived perennials, unarmed; hairs simple; flowers white; fruits purple-black 2
1b. Not as above 3

2a. Inflorescence a short cyme; berries usually dull; seeds mostly < 40 per berry ..... *S. nigrum*
2b. Inflorescence umbellate, berries usually shiny; seeds mostly > 50 per berry ..... *S. americanum*

3a. Plant glabrous or nearly so, dull green; prickles prominent straight, straw-coloured; berry dull green or flushed purple; seeds paper-thin ..... *S. pungunculiferum*
3b. Not as above 4

4a. Large shrub or small tree; inflorescence erect compound; flowers white; fruits usually yellowish; weedy species 5
4b. Not as above 6

5a. Unarmed small tree; leaves entire; ripe berry succulent, pubescent ..... *S. erianthum*
5b. Strongly armed small tree; leaves lobed; ripe berry firm, mucilaginous, glabrous ..... *S. torvum*

6a. Erect or spreading subshrubs; flowers white; fruits red, not enclosed in calyx 7
6b. Not as above 8

7a. Fruiting pedicels erect or nearly so; berry < 1 cm diameter ..... *S. tetrandrum*
7b. Fruiting pedicels pendant; berry > 1 cm diameter. ..... *S. yirrkalense*

8a. Plants sprawling, more or less prostrate 9
8b. Plants erect or spreading 11

9a. Slender plants; leaves mostly < 6 cm long; fruits usually 1 or 2 per cyme ..... *S. echinatum*
9b. Stout, vigorous plants; leaves mostly > 6 cm long; fruits several per cyme 10

10a. Leaves grey-green, slightly discolorous, densely pubescent; fruits 2 or 3 per cyme [eastern Top End and Gulf of Carpentaria] ..... *S. seitheae*
10b. Leaves often dark green or purple-green above, discolorous, finely pubescent; fruits up to 10 per cyme [western Top End and Bonaparte Gulf] ..... *S. lucani*

11a. Male and fruiting plants separate; male flowers numerous on erect cymes; bisexual flowers solitary; fruits enclosed by calyx 12
11b. Male and bisexual flowers on the same plant; bisexual flowers usually solitary at base of male flowers; fruit visible between calyx lobes 14

12a. Leaf upper surface glabrous or with just a few stellate hairs along veins ..... *S. asymmetriphyllum*
12b. Leaf upper surface densely stellate hairy all over 13

13a. Outer stems with abundant, long, slender prickles.. ..... *S. dioicum*
13b. Outer stems without prickles or with just a few short, conical prickles ..... *S. sejunctum*

14a. Plant sparsely armed; flowers white or nearly so; few (3 or 4) male flowers per inflorescense; fruit usually >50 mm long, mostly shiny purple-black ..... *S. melongena*
14b. Plants usually well armed; flowers purple, numerous (>6) male flowers per inflorescence, berry < 35 mm diameter, mostly pale yellow or whitish 15

15a. Mature calyx not reflexed ..... *S. chippendalei*
15b. Mature calyx strongly reflexed 16

16a. Perennial shrub; tomentum rusty; calyx lobes of bisexual flowers 5–7 mm long [south-eastern Top End and Gulf of Carpentaria]... *S. melanospermum*
16b. Annual or biennial subshrub; tomentum yellow-green; calyx lobes of bisexual flowers 10–13 mm long [Arnhem Land] ..... *S. clarkiae*

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